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Colour Based Detection in Clinical Diagnostic Methods Using a Portable and Simple Instrument

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ABSTRACT:

The paper describes a colour indicating instrument using a simple RGB sensor and a microcontroller. It can sense colour quantitatively and hence can be useful for colour based reagent added clinical diagnostic tests. Where colour is used for estimation of results in such tests, visual observation gives a rough estimate, while spectrophotometric observation would yield more precise results. In this instrument, even with the simple sensor, using extensive software based on colour theory involving the C.I.E. Chromaticity diagram has helped precise estimation of colour from test solutions. The evaluation testing was done using coloured objects and the instrument could indicate the colour value in hue and purity, so that comparisons between observations of tests conducted can be more accurate.

Key words*:* Clinical Colour identification, Colour changing bio-reactions, Provotech colour sensor, Hue, Saturation of Colours.

INTRODUCTION

Vision is one of the five senses for human perception in this world. The characteristic of human visual perception is colour. The cones & rods in our human eye is responsible for the perception of image in our eye. A pure colour or spectral colour is a single wavelength based light as in a laser. But practical sources of light are wideband, though the peak value of its intensity may be at a particular wavelength. The study of the representation of various colours visibly important is useful both scientifically and practically. What our vision tells about a colour is based on the reflected light from the object which appears to be coloured. No matter how one views an object, by a direct or oblique angle, the perception of the object's colour will not change, which is a property called "colour constancy". Thus it is vital to know sufficiently about the theoretical aspects of colour perception if one has to develop methods of recognizing colours of objects, distinguishing them based on their colours and also for synthesizing colour from available coloured materials.

In an attempt to detect coloured objects, at first we employed Light Dependent resistors tinted with colours. The outputs from them were gain adjusted for white balance. However, we came across the Provotech colour sensor [1] which has tinted Red, green and blue photo-diodes whose outputs are white balanced by added internal SMD resistors in series. In this sensor, four white LEDs are used as a compact p.c.b. module. These LEDs can be replaced if necessary by other light sources suitably focused on the object. These sources could be a combination of halogen tungsten lamp, florescent miniature tube and high brightness white LEDs.

The paper is organized as follows: The principles of reflected and measured light by any sensor as comprising the several components are described. The colour classification methods using the International Commission on Illumination (C.I.E.) and the Chromaticity diagram [2] are discussed. Further, the actual implementation of colour measurement with an AVR microcontroller on an LCD display is given.

CHROMATICITY

As per the CIE diagram, any colour can be stated in terms of the two (x, y) co-ordinates on this graph, shown in fig. 1. The entire range of colours perceived by humans is a function of these two colour co-ordinates [4]. The diagram can be used to find the hue and saturation of a reflecting object's colour as well. For any wavelength of light in the visible spectrum, the tristimulus values needed to produce the colour corresponding to that wavelength can be obtained directly from curves or tables that have been compiled from extensive experimental results.

The Red, Green and Blue photodiode output voltages from the Protvotech sensor can be likened to the CIE specified tristimulus values, which can be stated as X, Y and Z. This is true because the outputs of the photodiodes with colour tints on them is balanced for white light using trimmed resistors.

The tristimulus values of vision for the three colours Red, Green and Blue can be used to determine the chromaticity co-ordinates by taking the following ratios. If the sum (X+Y+Z) is called the total tristimulus sum (TS), then we can find the proportions of the Red chromaticity and the Green Chromaticity are given by

$$x = \frac{X}{TS}$$
$$y = \frac{Y}{TS}$$
$$z = \frac{Z}{TS}$$

...(1)

Here, the x, y, z are the components of Red, Green and Blue respectively. The z co-ordinate is not required because it can be found from x and y.

A colour other than these main colours can be found by plotting the (x, y) point on this graph and looking at the colour indicated therein. The various colours and its corresponding wavelengths are given in the diagram (Fig.1). This figure dates back to 1931 and many other projected plots have also been published, though this figure alone is referred to in literature. A certain small area on this diagram represents a particular visibly identifiable colour. That is how the figure has shown colours of different names in this figure [3].

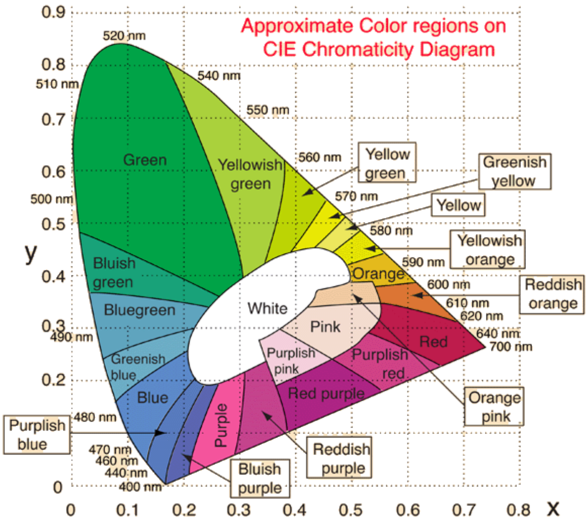

Fig.1 Chromaticity diagram with x and y being the Red and Green co-ordinates

THEORY OF COLOUR MEASUREMENT

What our vision observes from the light

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reflected from the object depends on three factors [6, 7]:

i) The source of light shone on the object;

ii) The emissive properties of the object, which may very often vary from point to point on its surface profile;

iii) The vision's sensitivity variations among the various colours.

1. The reflectance values of the object's surface at different wavelengths w1¬, w2,... wn are specified by R. The same has to be multiplied by the spectral power distribution of the illuminant P at each wavelength w.

$$R(w_1)P(w_1), R(w_2)P(w_2), \ldots, R(w_n)P(w_n) \quad \ldots(2)$$

2. Multiply the products of Step 2 and sum up to get the tristimulus values

$$R(w_1)P(w_1)x(w_1) + \ldots + R(w_n)P(w_n)x(w_n) = X$$

$$R(w_1)P(w_1)y(w_1) + \ldots + R(w_n)P(w_n)y(w_n) = Y$$

$$R(w_1)P(w_1)z(w_1) + \ldots + R(w_n)P(w_n)z(w_n) = Z$$

...(3- 5)

The tristimulus values known as X,Y and Z are actual numbers when sensed by a photo sensor with coloured filters for Red, Green and Blue. In using the Provotech Sensor, the photodiode outputs are directly giving these X,Y and Z values because the light source is internally generated by the sensor and white balance trimming is provided in the unit.

OBJECTIVES IN COLOUR MATCHING

Automation is the solution when the tasks needs to be done repetitively. The machines can perform the highly repetitive tasks of sorting the objects based on their colour. The human inspection of performing tasks over & over again eventually fail to recognize the colour of the product. Thus, automation of tasks result in improving the efficiency of the manufacturing system [4, 5]. The objective in automated colour measurement is to design such a circuit to detect the colour and instantly display it .

GENERAL MEASUREMENT TECHNIQUES FOR COLOUR INFORMATION:

1. The reflected light from the object can be sensed by using LDR's, the output of the sensor is given to the signal conditioner and compared for detecting the colour of the object.
2. The reflected light from the object can be sensed by using a Provotech sensor [1].
3. There are colour sensor units available. They use four white coloured bright LEDs in the four corners of a square printed circuit board. At the centre of this board are fixed SMT photo diodes. The top surface of these diodes which are very tiny and size 1mm square are painted with translucent pigment coatings of the red, green and blue colours. The choice of these pigments of course decides the matching accuracy of the colour of the sensed object (Fig. 3).

RECORDING TECHNIQUE USING A MICROCONTROLLER

The Arduino circuit for the colour identification circuit is shown in fig.2. The figure 3 shows a basic measurement of colour of a typical purplish red object. The software for most colour (matching applications has been developed by using the IDE OSHON AVR simulator. This provides for easy BASIC language based program development [9]. The programming algorithm is given in figure 5.

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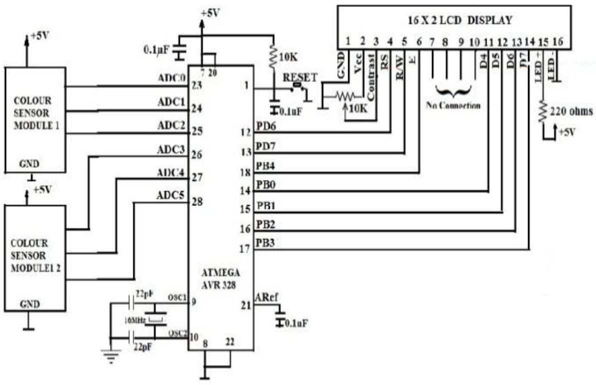

Fig.2. Circuit diagram of the Color Measuring unit.

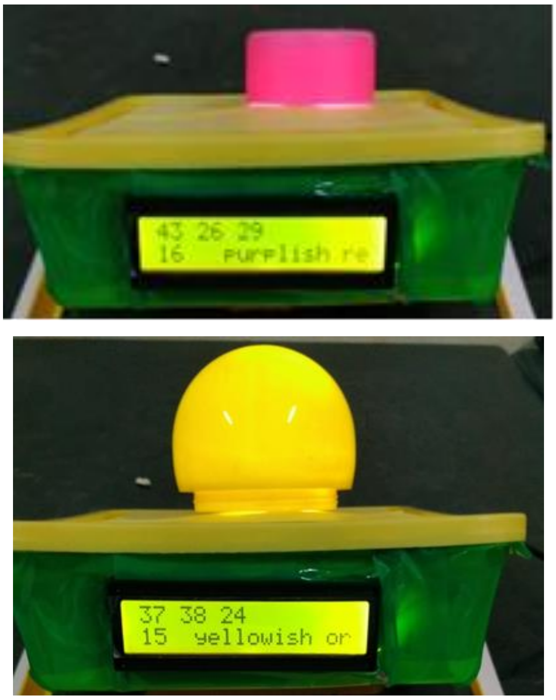

Fig.3 Photograph showing some objects and displaying their colours.

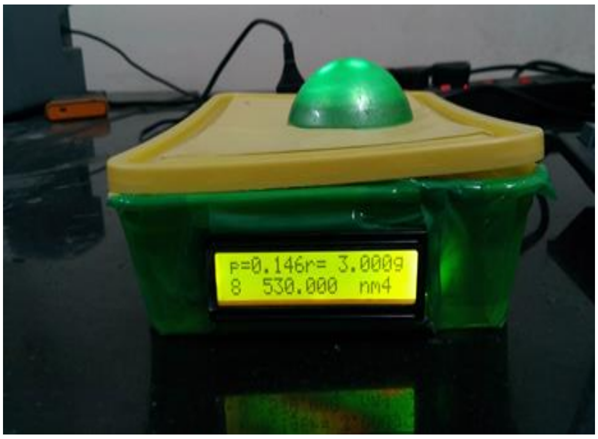

Fig.4. Showing the Hue and Purity (P) value of a reflected surface. (530 nm), 8 is hue index.

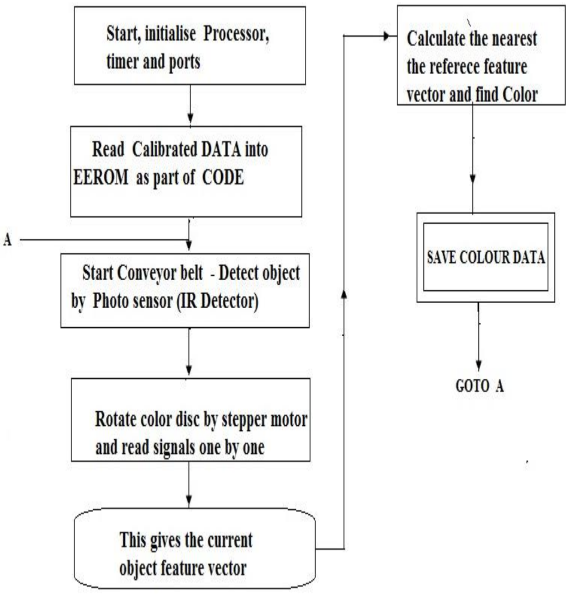

Fig.5. Flow chart for colour identification of the object's colour using Provotech Sensor

HUE BASED REALISTIC ESTIMATE

The Reference [11] has shown techniques for colour measurement in some detail but as yet, there is no work reported on exact hue determination from a simple colour sensor. For this purpose, we have to determine the chromaticity co-ordianates and use them on the fig.1 to evaluate hue.

The calculation of the distance d of the point (r,g) to the straight line $ax+by+c=0$, of hue H (530nm as in fig.8) can be found from the geometrical formula as

$$\text{Distance}\ (ax+by+c=0,\ (r,g)) = \frac{|ar+bg+c|}{\sqrt{a^2+b^2}} \qquad ...(3)$$

The different straight lines can be represented by the equations

$$a_i x + b_i y + c_i = 0 \qquad ...(4)$$

So, the foot of the perpendicular from the X, Y coordinates of the object to such a line will

be indicating the relative saturation or whiteness of the colour, while the line itself will indicate the hue as so many nanometers.

SURVEY OF APPLICATIONS FOR ENVIRONMENT

One area of application that is found in practice is the attractive colour printing on the packaged processed food type products. The process has involved the theory of colours because, in order to obtain a specific novel colour other than the plain red, green or blue ones, the CIE diagram tells that a new colour can be synthesised by mixing the permitted colours in proportions which could be determined by geometrical calculations from the co-ordinates of the available colours and the co-ordinates of the required colour[12]. The colour of the object needs to be identified to match the synthesized coloured objects such as in textile, plastic products, paper and food industries etc. F. Yuel et al [13] have described how automotive components are varied in colour and it is not quite a simple task to differentiate them by their colours, particularly in a production line of fast assembly. Another more critical application has also been referred to by these authors, which pertains to assembly pharmacological products with different packing manners and colour distinctions among tablets of different doses. By using the above principles, the colour information is measured with suitable sensor.

CONCLUSION:

The colour sensor which is ideal for detecting colours helps to sense quantitatively colour changes in any clinical reagent based reaction and can be implemented even in very small volume targets. The Provotech Sensor is compact, tiny enough and quite sensitive. A typical analytical instrument is developed by using this cost effective Photo diode array along with a simple ATMega AVR 328 microcontroller. Using the colour sensor cited before, with programs for fixing the colours on the CIE diagram from the measured outputs of the colour tinted photo diodes, it is possible to detect not merely light from reflected objects but also burn wounds under prophylaxis, (not shown in our figures). Particular mention should be made about the simplicity, compactness and battery operability of this module. Ease of software development with IDE OSHON Software with Computer communication via serial communication interface. This work could be extended for all the hues indicated in fig.1 and saturation from 0 to 100%.

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